



## Integrated System for Autonomous Science

The New Millennium Program Space Technology 6 Project Autonomous Sciencecraft software implements an integrated system for autonomous planning and execution of scientific, engineering, and spacecraft-coordination actions. A prior version of this software was reported in "The TechSat 21 Autonomous Sciencecraft Experiment" (NPO-30784), *NASA Tech Briefs*, Vol. 28, No. 3 (March 2004), page 33. This software is now in continuous use aboard the Earth Orbiter 1 (EO-1) spacecraft mission and is being adapted for use in the Mars Odyssey and Mars Exploration Rovers missions. This software enables EO-1 to detect and respond to such events of scientific interest as volcanic activity, flooding, and freezing and thawing of water. It uses classification algorithms to analyze imagery onboard to detect changes, including events of scientific interest. Detection of such events triggers acquisition of follow-up imagery. The mission-planning component of the software develops a response plan that accounts for visibility of targets and operational constraints. The plan is then executed under control by a task-execution component of the software that is capable of responding to anomalies.

*This program was written by Steve Chien, Robert Sherwood, Daniel Tran, Benjamin Cichy, Ashley Davies, Rebecca Castaño, Gregg Rabideau, Stuart Frye, Bruce Trout, Seth Shulman, Thomas Doggett, Felipe Ip, Ron Greeley, Victor Baker, James Dohn, and Darrell Boyer of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (818) 393-2827. Refer to NPO-41993.*

## Montage Version 3.0

The final version (3.0) of the Montage software has been released. To recapitulate from previous *NASA Tech Briefs* articles about Montage: This software generates custom, science-grade mosaics of astronomical images on demand from input files that comply with the Flexible Image Transport System (FITS) standard and contain image data registered on

projections that comply with the World Coordinate System (WCS) standards. This software can be executed on single-processor computers, multi-processor computers, and such networks of geographically dispersed computers as the National Science Foundation's TeraGrid or NASA's Information Power Grid. The primary advantage of running Montage in a grid environment is that computations can be done on a remote supercomputer for efficiency. Multiple computers at different sites can be used for different parts of a computation — a significant advantage in cases of computations for large mosaics that demand more processor time than is available at any one site. Version 3.0 incorporates several improvements over prior versions. The most significant improvement is that this version is accessible to scientists located anywhere, through operational Web services that provide access to data from several large astronomical surveys and construct mosaics on either local workstations or remote computational grids as needed.

*This program was written by Joseph Jacob, Daniel Katz, Thomas Prince, Graham Beriman, John Good, and Anastasia Laity of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

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terdependencies among operations, and possibly frequent changes in governing schedule requirements. Unlike many other scheduling software systems, Aurora focuses on resource requirements and temporal scheduling in combination. For example, Aurora can accommodate a domain requirement to schedule two subsequent operations to locations adjacent to a shared resource. The graphical interface allows the user to quickly visualize the schedule and perform changes reflecting additional knowledge or alterations in the situation. For example, the user might drag the activity corresponding to the start of operations to reflect a late delivery.

*This program was written by Richard Stottler, Annaka Kalton, and Aaron Bell of Stottler Henke Associates, Inc. for Kennedy Space Center.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

*Richard Stottler*

*Stottler Henke Associates, Inc.  
951 Mariner's Island Blvd., Suite 360  
San Mateo, CA 94404  
Phone: (650) 931-2700  
E-mail: stottler@stottlerhenke.com*

*Refer to KSC-12569, volume and number of this NASA Tech Briefs issue, and the page number.*

## Utilizing AI in Temporal, Spatial, and Resource Scheduling

Aurora is a software system enabling the rapid, easy solution of complex scheduling problems involving spatial and temporal constraints among operations and scarce resources (such as equipment, workspace, and human experts). Although developed for use in the International Space Station Processing Facility, Aurora is flexible enough that it can be easily customized for application to other scheduling domains and adapted as the requirements change or become more precisely known over time. Aurora's scheduling module utilizes artificial-intelligence (AI) techniques to make scheduling decisions on the basis of domain knowledge, including knowledge of constraints and their relative importance, in-

## Satellite Image Mosaic Engine

A computer program automatically builds large, full-resolution mosaics of multispectral images of Earth landmasses from images acquired by Landsat 7, complete with matching of colors and blending between adjacent scenes. While the code has been used extensively for Landsat, it could also be used for other data sources. A single mosaic of as many as 8,000 scenes, represented by more than 5 terabytes of data and the largest set produced in this work, demonstrated what the code could do to provide global coverage. The program first statistically analyzes input images to determine areas of coverage and data-value distributions. It then transforms the input images from their original universal transverse Mercator coordinates to other geographical coordinates, with scaling. It applies a first-order polynomial brightness correction